THE BLACKSMITH'S POCKET BOOK

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THE BLACKSMITH'S POCKET BOOK

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PREFACE.

In writing this book the object I have in view is first to put before the apprentice, and to answer, that frequent question: "How would you make it?"; then to explain to the general smith and toolsmith in as simple and as interesting a manner as possible modern methods of smithing. I have carefully avoided unnecessary reading matter, as the sketches will show at a glance what to do. I have also included a list of "don'ts" for the general smith and toolsmith.

The treatment throughout is based on practical experience and will, I believe, be a valuable aid to all blacksmiths and progressive workers.

TOM WORMALD.

Wakefield, *September*, 1921.

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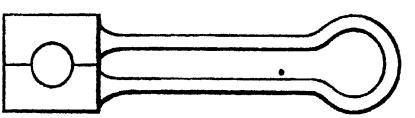
CHAPTER I.

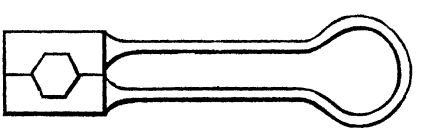
Introduction of Apprentice to Shop Tools.

We will begin as if introducing a new apprentice to the shop, and then follow on accordingly. We will assume he has been in the shop eighteen months or two years and has made his tongs and a few other things, for it is most important that the apprentice should make his own tools suitable to his own requirements, and for the class of work he is engaged upon. They should be made light and easy to handle; it is a most important part of his trade to be able to use and handle the tools freely and with ease, as there is a certain amount of skill even in the use of the hand hammer. The following sketches show a few tools used under the steam hammer.

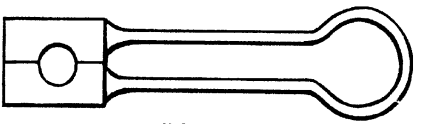
Some Tools used under the Steam Hammer.



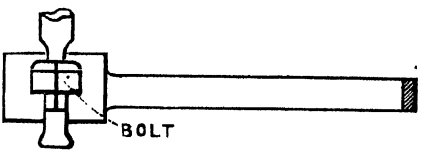
Round swages.

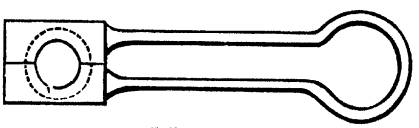


Hexagon swages.

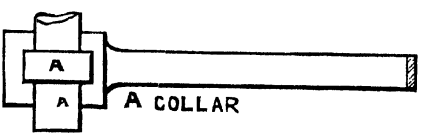


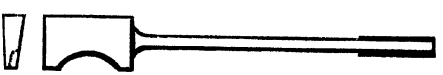
Bolt swages.



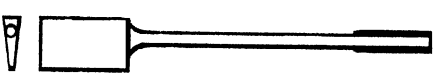


Collar swages.

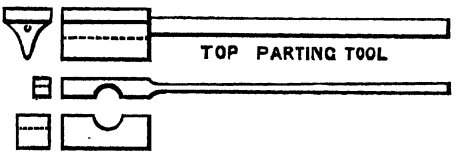




Side fuller or necking tool.

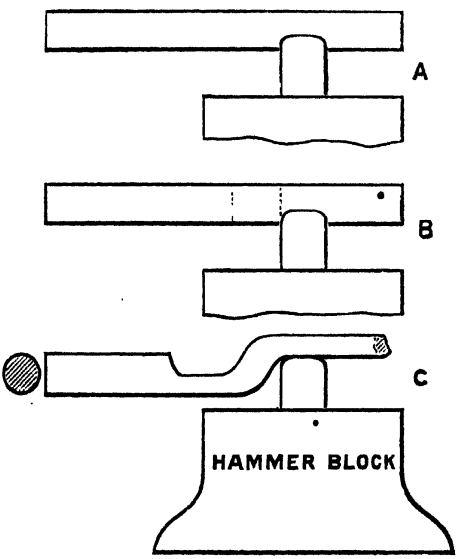


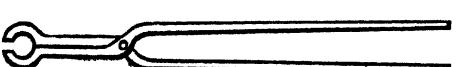
Cleaver.



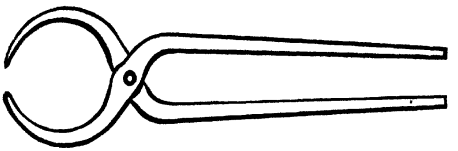
Chopping tools for cold iron.

SOME HAMMER TOOLS.



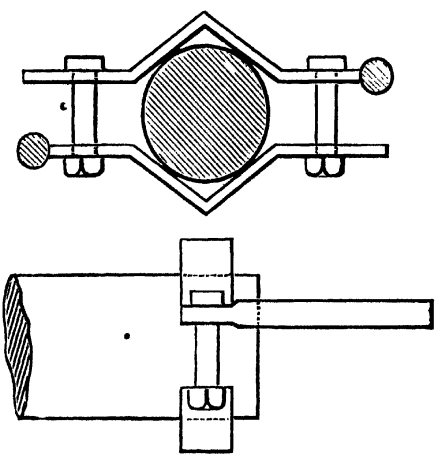


Set tongs.



Bow tongs.

The above sketches show how to make tongs by three turns to the right. Shanks can either be drawn out solid or welded on; the latter is the best and most serviceable way.



Pair of clamps for hammer work. When the piece is very short and heavy for the clamps, a very good plan is to have two pieces of piping and to fit them on the handles for leverage.

How to draw Steel and Iron under the Hammer.

In drawing out steel under the hammer, the best and quickest way is to "pinch" it, that is to put a little bit under at once; by so doing you prevent the hammer from making the steel solid and not drawing it longer. It is possible for one man to make a certain piece of steel come longer than another by this method. If you are drawing out a large piece under, say, an 8-cwt. hammer, which is assumed to be employed for most of the forging in this book, a very good plan is to place a piece of flat iron, say, 2 ins. × $\frac{3}{8}$ in. on top of the steel, and move it at almost every blow of the hammer; this will stretch the steel and prevent the face of the hammer from taking up the heat out of the steel. The same method is very useful if you want to get the full width from a certain piece of steel or iron. In this case the piece of iron or "spreader" should be put on the opposite way. In drawing out round steel or iron, it should first be made square to as near the size as possible, and then the corners hammered off to make it round, as by hammering a piece of round steel too much you will make it hollow in the middle, and by hammering round iron you will make it split.

In drawing out cast steel the blows of the hammer should be hard and sharp, not allowing the hammer to stop on the hot metal sufficiently to cool the surface of the steel.

How to draw out Iron.

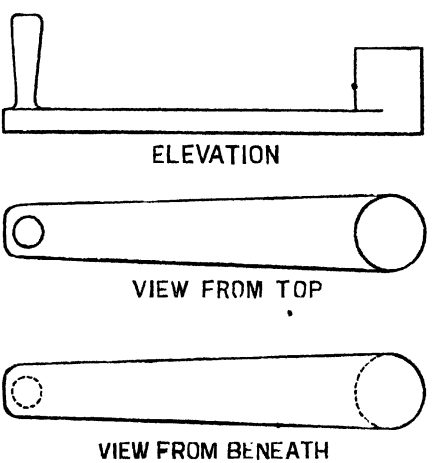
When forging iron under the hammer, especially small iron, have a welding heat at the point, and

work from the end, a short length at a time. This will prevent the iron from splitting. If you want to make it round have it square for a start, and as near the size as possible. Forge as near to sizes as possible before putting it in the swages, as, if too large, it will be very hard to turn, and the swages will take out the heat.

CHAPTER II.

Reading of Drawings and Small Work.

The reading of a drawing can scarcely be explained without examples, but a few hints may be useful to the apprentice. In the first place, the drawing should always be fixed on a board so that it can be seen at a glance. The machined parts are not always, but should be, lined in red and should be



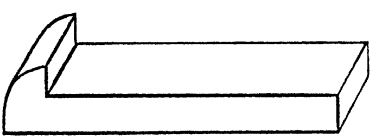
Sketches showing lever turned over two different ways to illustrate dotted lines in a drawing; these show the boss on the opposite side as if looking through the lever. The full lines show the boss on same side.

plainly figured. The general drawing is not very useful in the smithy.

All drawings are drawn to some definite scale; quarter, half, and full size are generally used, and one-eighth occasionally, according to the size of the forging. Quarter size means 3 ins. to 1 ft. or ¼ in. to 1 in.; half size, 6 ins. to 1 ft or ½ in. to 1 in.; ⅛ in. to 1½ ins. to 1 ft. or ⅛ in. to 1 in.

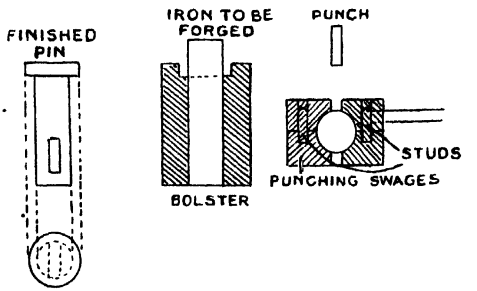
Forging a Key.

For our first real job we will take an ordinary key which, if made properly, is a very good beginning for an apprentice. If it is to be made to file up it must be made to sizes given, otherwise, either the fitter is going to have a lot to file off, or it will be too small. The callipers should be set to the sizes and closely worked to.

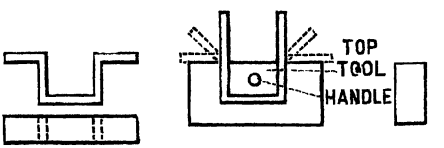


Key.

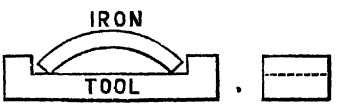
A bolster is first used in the making of iron pins; a straight piece of iron is jumped in the tool under a hammer. The headed blank is then placed in a pair of swages for punching cotter holes. Two studs should be screwed in the bottom swage and holes made in the top for keeping the swage in position while punching.



Tools for iron pins.

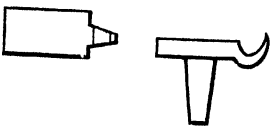


Tools for bending staples.



Tool for jumping flat iron in the middle. The iron is bent and flattened down under the hammer.

Tool for making split pins.



Anvil tool for chain welding.

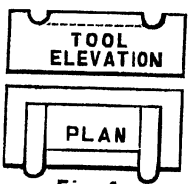
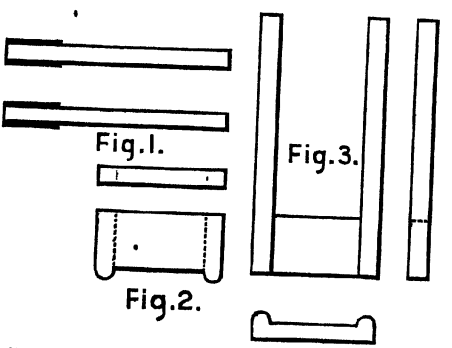


Fig.4.

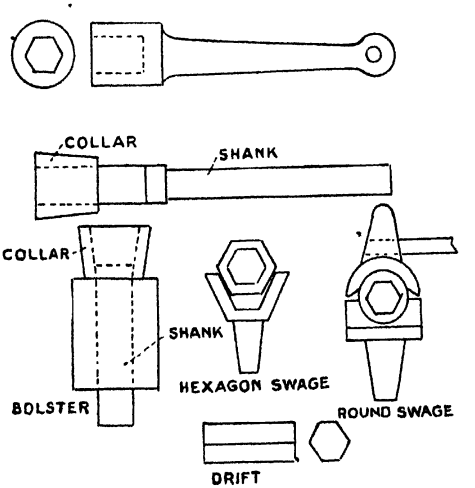


Belt fork in different stages, and tool for making same under hammer.

Fig. 1.—Ends jumped ready for welding.
Fig. 2.—Middle scarfed.
Fig. 3.—Finished fork.
Fig. 4.—Tool used.

Box Key.

The following sketches show how to make a box key, which is really three jobs in one—a pin, a collar, and a bolt-head. The collar and shank in bolster show the method of fastening, the shank before welding the collar being slightly tapered.



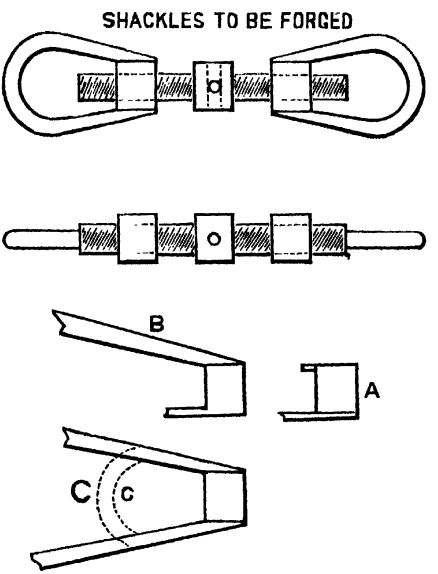
Sketches showing how to make a box key and the various tools used.

Drop the shank through the collar in the bolster and then have a punch inside the collar; a few blows will fasten the shank so that it will not come out when welding, when hot bring it out and put it in the swage and strike the shank side so as not to

close the hole more than necessary. Next have another welding heat, put in the drift in the hexagon swage, make it hexagon inside and out to make a good fit for the nut. Finish off in third round swage. Have the collar about half an inch larger than across corner of nut for a start to allow for closing.

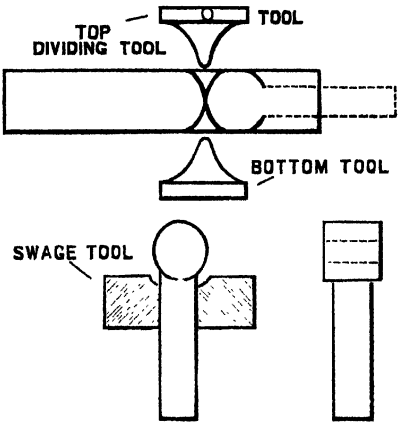
CHAPTER III.

General Smithing.

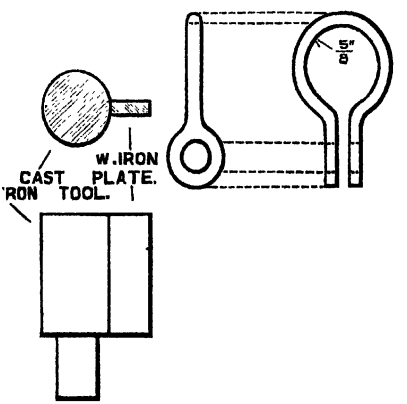


A pair of shackles for chain for holding a boiler or cylinder on a waggon.

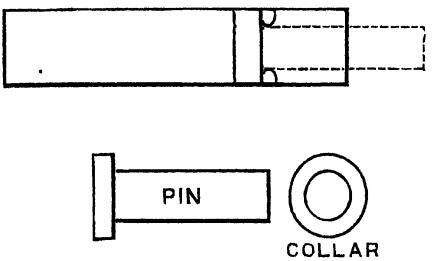
Sketch A shows a piece of iron with a piece drawn down for holding while the first side is welded on as shown at B. Then cut the short piece off and weld on the other side as shown at C. The sides are then bent over and welded at the junction.



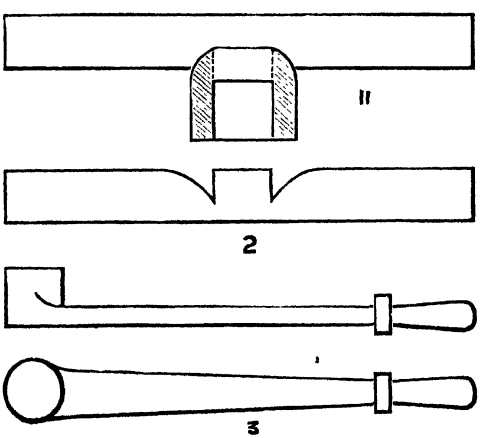
Eye rod end and tools for making.



Shackles and tool for bending same.

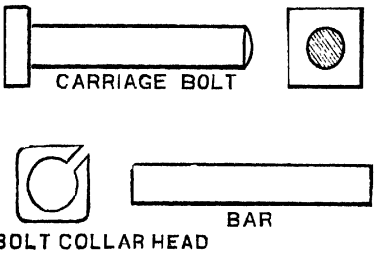


The making of a pin.

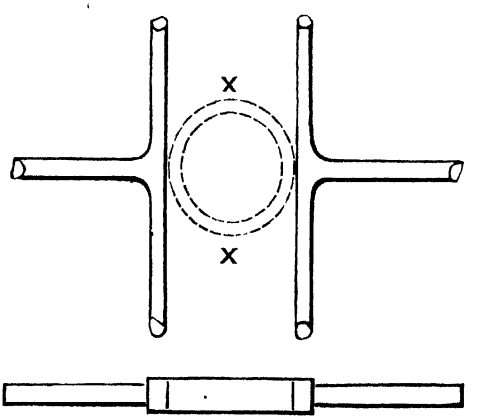


How to make a hand lever; old method used in a new way.

An old method of forming a lever end can be greatly improved. In place of a die or stamp have a bolster with the corners tapered off and drop a piece of steel in the bottom, of a height corresponding to depth of lever boss.

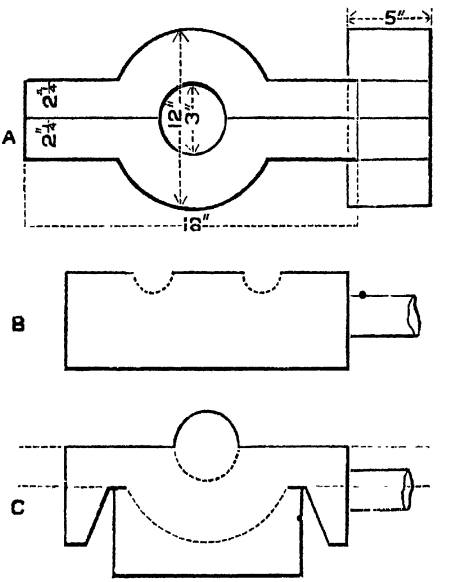


Sketch showing the making of a bolt and bolster.



Strap or handle for foundry ladle. The T-pieces can either be welded on or drawn from the solid. The latter method is the better. The flanges are then bent over and welded together on each side at X.

The following sketches show the making of a pair of clamps, roughed out and ready for being bored out. Fig. A shows them finished. Fig. B shows one part after it has been forged to size and marked down to width of swage. Fig. C shows the part

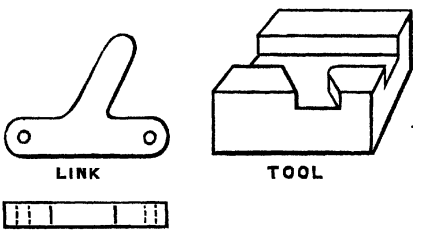


Sketches of pair of clamps.

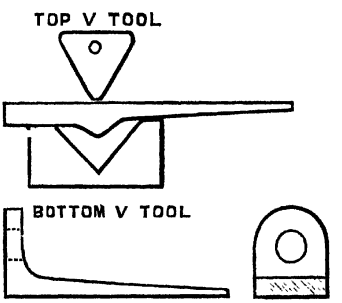
upside down in swage. It is flattened down until the swage is full and ends are of the proper thickness, then a piece of round bar is put on top as shown. It is repeatedly taken out of the swage and flattened to proper width. The ends are then drawn out.

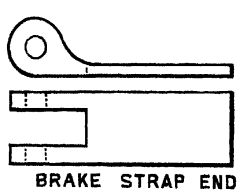
CHAPTER IV.

Hoop Welding and Brake Gear.



Sketch showing horn link for endless chain, also tool for making same.





Sketches showing how to make brake strap ends.

The following sketches show a fork lever or lifting lever. First, rough out the steel to largest size

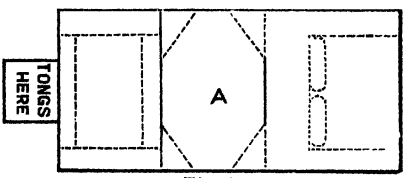


Fig. 1.

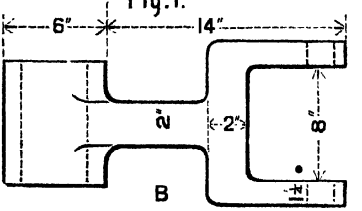


Fig. 2.

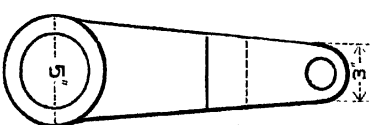


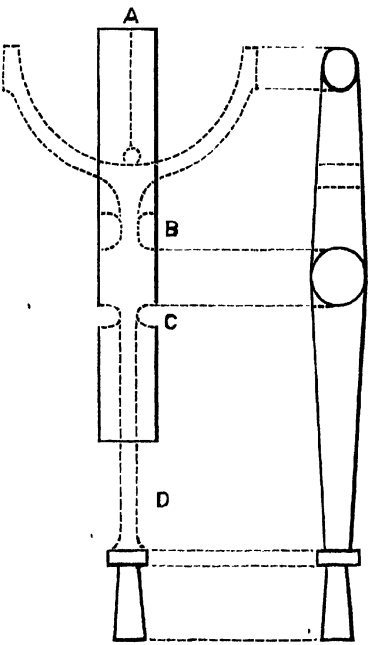
Fig. 3

The above sketches show fork lever. Fig. 1 shows the same being roughed out; lotted lines show where the throat is punched and cut out, where piece is taken down by V-tool for being drawn out in middle, and where end is drawn down for boss.

required, then take down centre piece with V-tools and draw out. Next punch two cotter holes in throat of joint and cut out to dotted lines. Take

hold opposite end and draw boss end; punch hole and dress up to sizes.

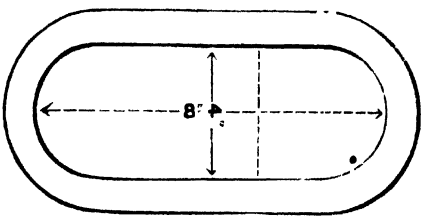
The following sketches show how to make a clutch lever. At the beginning of the work the

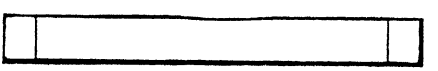


Making a clutch lever.

tongs would be at the end A. After drawing the piece out to size of largest part of lever, the part B would be taken down with two pieces of round iron.

A flat piece of iron is then placed at each side to put the boss central. Beyond the boss the part C is taken down by two pieces of round iron to the thickness of handle, and drawn out as far as part D. The handle may be finished next, but it is better to leave this for holding with the tongs. The end A is heated, a hole is punched, and the end split open. The split parts are straightened under the hammer and then bent to shape on a bolster.



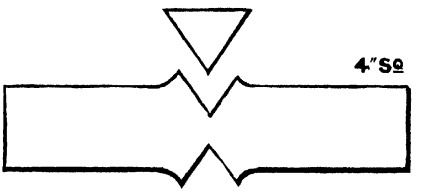


Kidney hoop.

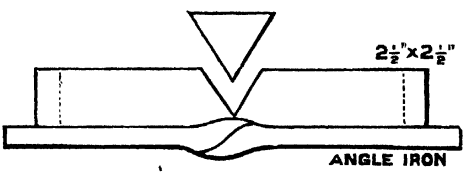
The above is a sketch of a kidney hoop Such hoops are best made in the same way as ordinary hoops. To find the length of metal required, add both width and length together, then halve it, for example, 8+4=12. Call it a 6-in. ring. Use the length for a 6-in. ring, weld and make round, then knock the sides in to given sizes.

WELDED JOINTS FOR HOOPS.

SCARFED JOINT



GLUTTED JOINT



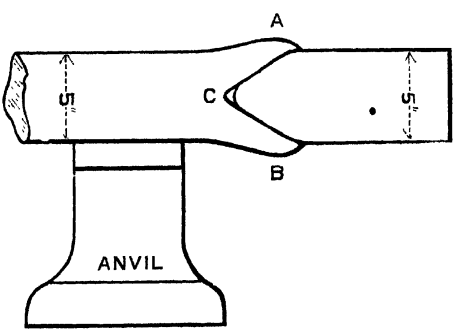
Angle iron hoop with scarf weld on edge and glut weld on top.

CHAPTER V.

Shaft Welding and Engine Forgings.

The following sketch shows how to weld a mild steel shaft. First jump the ends well up and then open the shaft end to a V-shape. Next taper off the piece to be welded in as shown. If the piece to be

V-Welding.

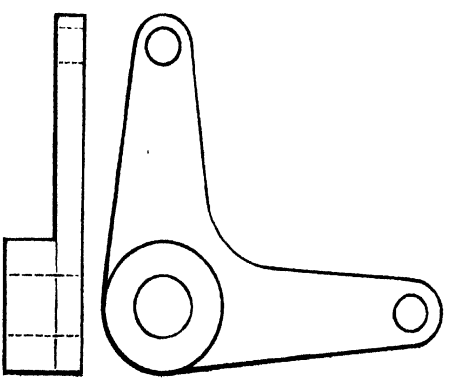


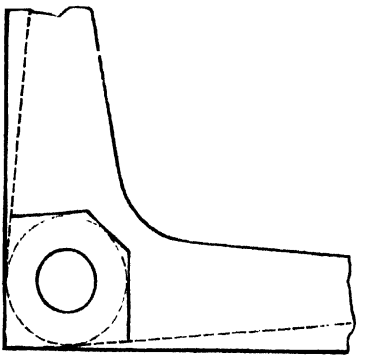
Welding a shaft. Exact shape of scarf for a good sound weld.

welded in is long or fairly heavy a stand of some kind should be provided to rest the piece on while it is being fixed in position. If it is very short a carrying-bar will do, one holding each side. Have two fires, one to heat the shaft and the other to heat the short piece. When hot have the tup ready and give a few steady blows at first. Let the tup press against

the end at each blow while the heat is fixed, then have another welding heat at A, and with the striking hammers weld the scarf and at B, one side at a time. Have a good welding heat all round and take under the hammer. Sometimes it will be necessary to have two wedges at C. If so, make two wedges from round or square iron and leave ends long enough. Get a welding heat on the shaft and heat the wedges on another fire also to a welding heat. Fill up the hole with borax and then put the wedge in and weld, knocking down with striking hammer. This will make a good sound job. Give another light heat under the hammer swage and finish to size.

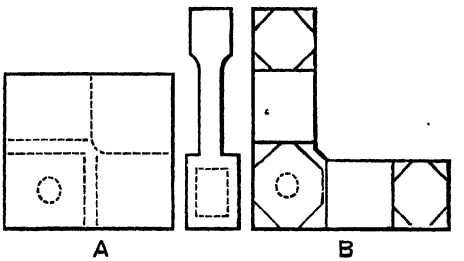
Sketches showing method of making angle lever. Dotted lines on boss show it marked out ready for finishing. The most important point is to mark lines on side when flattened out and cut off to

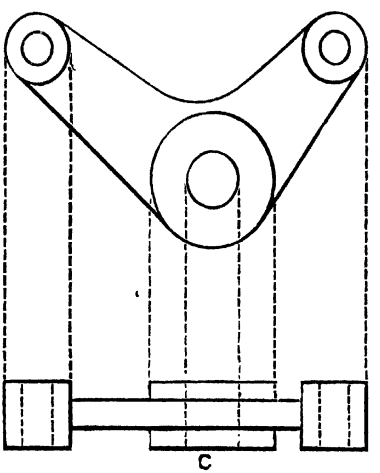




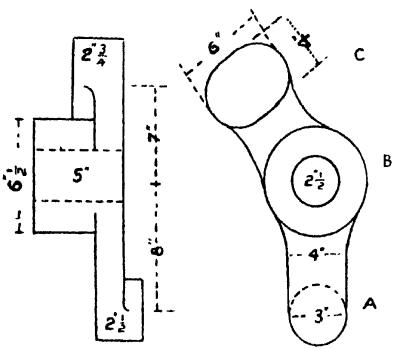
dotted lines with cleaver before drawing on edges. This keeps the lever at the proper angle.

The following sketches show another way of making an angle lever. A piece of square steel, Fig. A, is used, cut a piece out of the corner to the single dotted lines; next mark the sides to the double dotted lines with two pieces of round iron, one on top and one underneath, to the size of boss required. For the next step, if it is a fairly large lever, it is best to punch a small hole in the boss part, as it is very much easier to hold the lever with. It must be small enough to allow for boring out afterwards. Then draw out the ends as in Fig. B, scribe the bosses round with the compass, and dress up on anvil. Fig. C shows the finished lever.



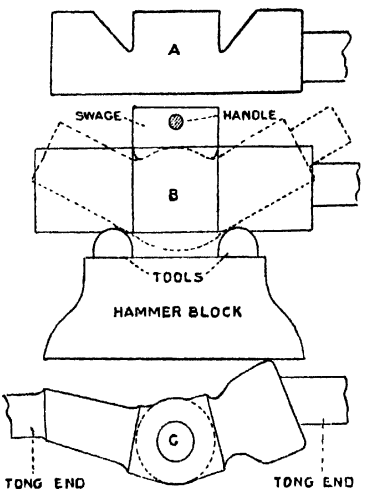


Angle lever roughed out and finished.



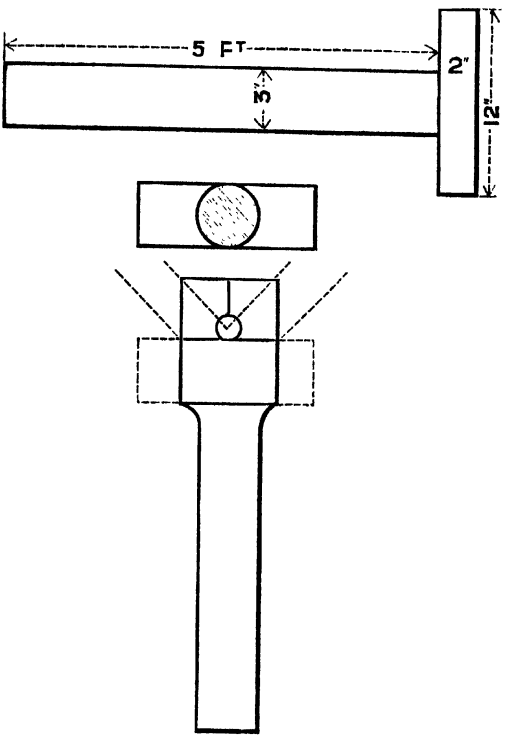
Sketch of mild steel valve lever. Sizes marked are merely to illustrate proportion of lever.

The following sketches show how a mild steel valve lever is roughed out. The most important thing about roughing out is to get it as near the angle as possible, and dress it up afterwards. A template should be made first. Sketch A shows the bloom taken down with the V-tool. Sketch B shows how to bend it. Have two pieces of half round metal on the hammer block and a swage on top as shown. When you have got the desired angle, punch the hole and then draw out the ends. Mark off the boss, round up, and let it cool. Mark off ends to suit. Sketch C shows how lever will appear when roughed out.



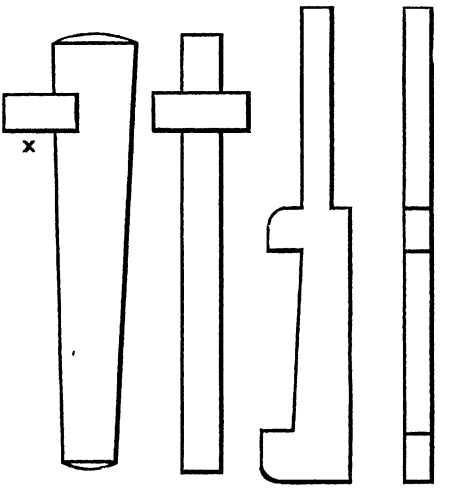
Sketches of mild steel valve lever—roughing-out process.

The following sketch shows a method of making a T-rod from solid steel. Draw out one end to form the stem, and leave a square piece on the other end. Punch a hole and cut open with cleaver. Open the ends as wide as possible with a V-tool laid on top, then make it hot, hold it under the hammer, and open the ends further with striking hammer. Next straighten off with the tup, and trim up on the anvil. This method is only used when it is not desirable to weld the end on. The T can be made much more easily by welding and jumping the end on under the hammer.



Sketch showing way of making T-rod without welding.

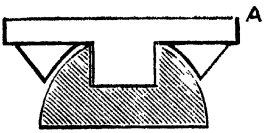
In making the cotter, a pair of swages are useful for rounding the part marked X. The gib can be drawn out in the middle under the hammer, or



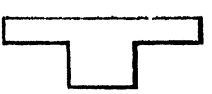
Sketch showing cotter and gib.

cut out on the anvil, according to the size, or it may be partly drawn out, and then a piece cut at each end to give proper length.

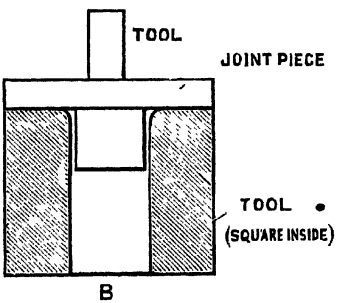
The following shows a very good way of making a hinge or knuckle joint with the tools. Fig. A shows section of tool with the steel ready for being taken out for the ends to be drawn out. Fig. B shows square tool, and the joint piece laid on the top of it ready for being forced down by a dressing tool. The ends can be cut round before or after coming out of this tool. Fig. C shows the finished joint.

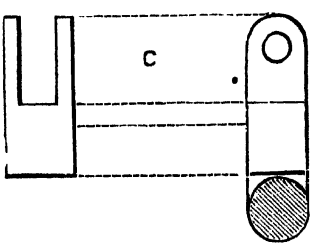


Section of tool.



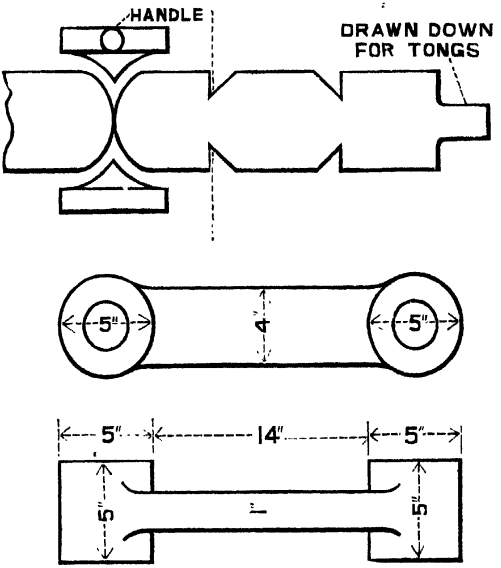
Joint piece with ends drawn out.



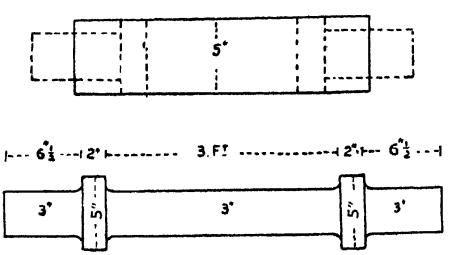


Finished joint.

Sketches showing method of making small knuckle joint.

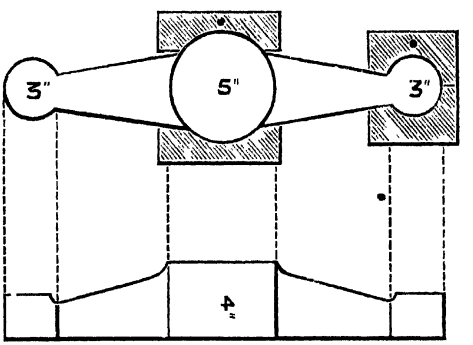


Roughing out a lever. In roughing out, dividing tools will be opposite way.



Making a shaft with collars.

The sketch at bottom of previous page shows how a shaft is roughed out and finished. The bar is marked round with a piece of iron from where it has to be drawn out. To find how much to mark for the middle, first get the diameter of the finished shaft, say 3 ins., multiply it by the length, say 36 ins., and divide by the area of the piece you are going to use, say 5 ins. Add about 1¼ per cent for heating and waste.

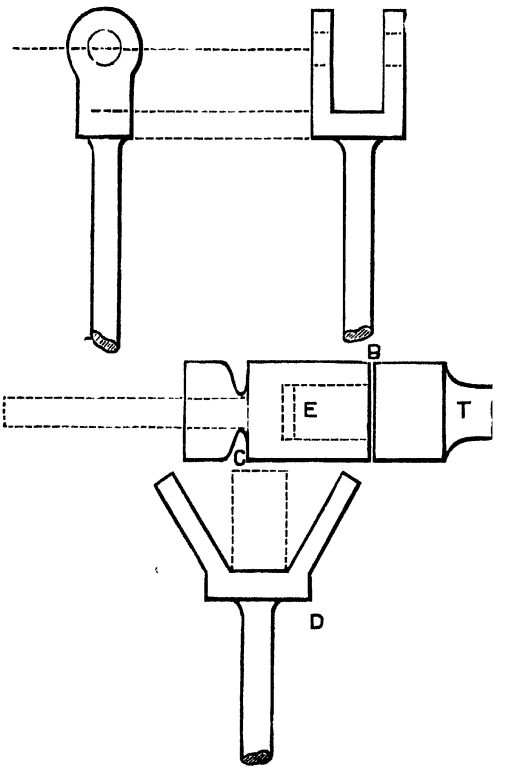


Steel cross bar showing suitable swages for forging the same.

Knuckle Joint.

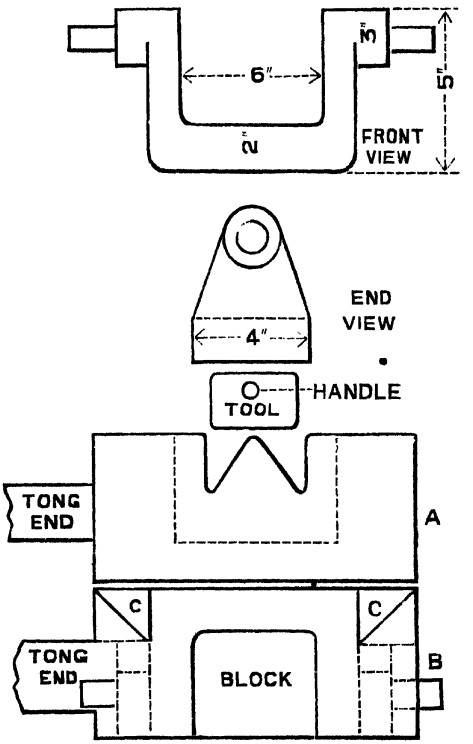
The following sketches show a way of making a knuckle joint at the end of a rod. One end, T, is drawn out for the tongs. The groove at C shows where to draw out from, and also how to make a clean shoulder. The shank is drawn out. The piece is cut off at B, and the tongs changed to the opposite end. A hole is punched and the end E is cut to the dotted lines, and then opened out as shown at D,

to straighten up the sides under the hammer. A dressing piece is used for closing back the sides to the proper shape.



Sketches of knuckle joint.

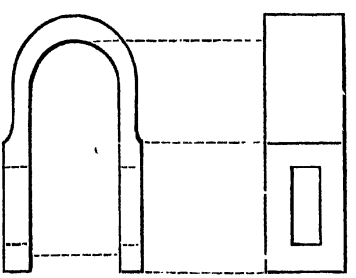
The following sketches show how to rough out a saddle for a stationary engine. The first two views



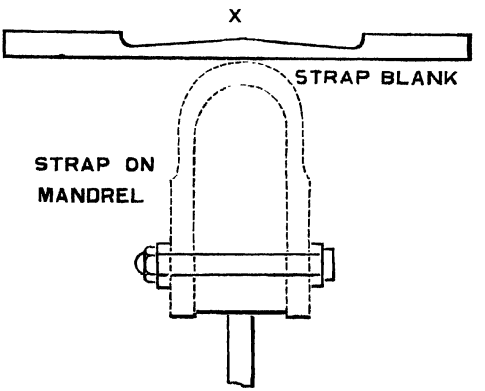
Saddle or cradle for engine.

show the finished forging, which is afterwards machined all over. Fig. A shows the first process. The piece is taken down with a V-tool and drawn out to the desired length between the web parts by a square tool on top. The forging is next turned upside down, as in Fig. B, and a square block is put underneath the part already drawn out. This holds it in shape while the V-tool is again used to form the ends. These are marked off with a square shoulder for the outside length. The corners C are narrowed down to the width of the collar, and a piece is cut off under the hammer, to save trouble when drawing out the ends. After roughing out one end the piece is turned end for end, and the other end is worked. The forging is trimmed upon the anvil.

MAKING A STRAP.

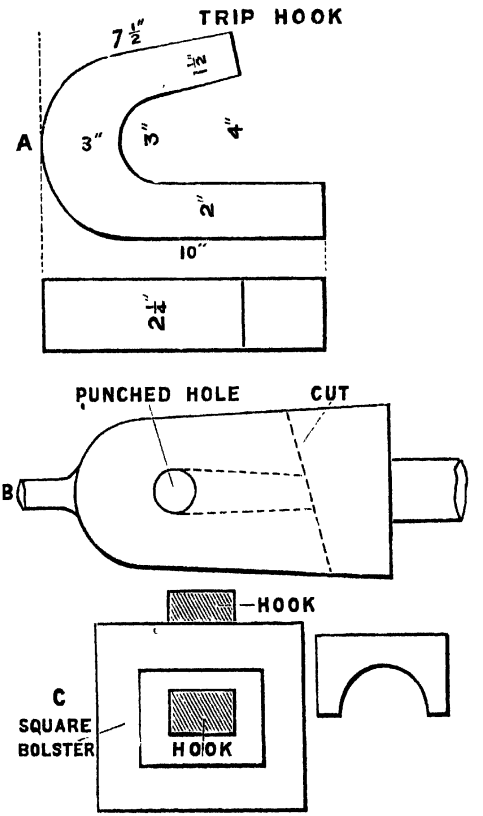


FINISHED STRAP



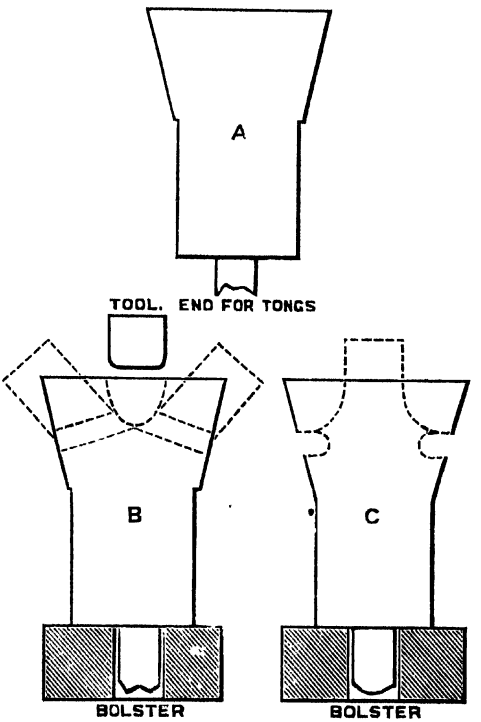
The blank strip is wider at the middle, X, to allow for stretching in bending. The bent piece is bolted to a mandrel for swaging up the bend.

The following sketch shows a trip hook made of mild steel. Fig. A shows the finished forging. In the first process, Fig. B, a piece is tapered down, and one end is drawn out for the tongs. Next it is cut off at the opposite end to the size required. A hole is punched and the end is cut out as shown by the dotted lines. After cutting open, the sides of the piece are separated by placing a V-tool on top. A hollow square bolster and a large swage, as shown in Fig. C, will be useful for straightening up the sides and shaping the bend.


TRIP HOOK
7½"
1½"
A
3"
3"
4"
2"
10"
2½"
PUNCHED HOLE
CUT
B
HOOK
C
SQUARE
BOLSTER
HOOK

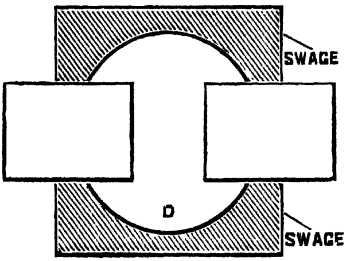
Making a Mild Steel Centre for Governor Gear.

One end of the blank is first drawn out, or the other end is jumped up, as shown in Fig. A. The tong



Governor centre—Roughing-out process.

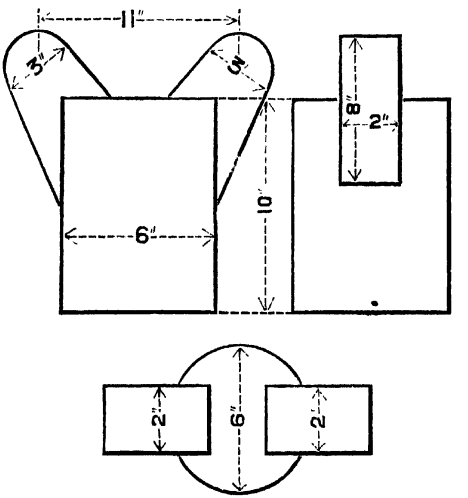
end is then placed in a bolster under the hammer, as in Fig. B, and the upper end is grooved with a round bar. A square tool with rounded edges is next used to open out the wings. The piece is taken out of the bolster and grooved at the sides, as



Governor centre in swages.

shown in Fig. C, and the ends of the wings are drawn out. The stem is then placed between top and bottom swages, Fig. D, which will draw out the base parts of the wings. It is then ready for trimming up.

To bend a hoop of this description first draw centre line on a piece of plate or floor, then mark off half width of hoop, in this case 7 ins. and 6 ins. From these two points draw line down until it cuts

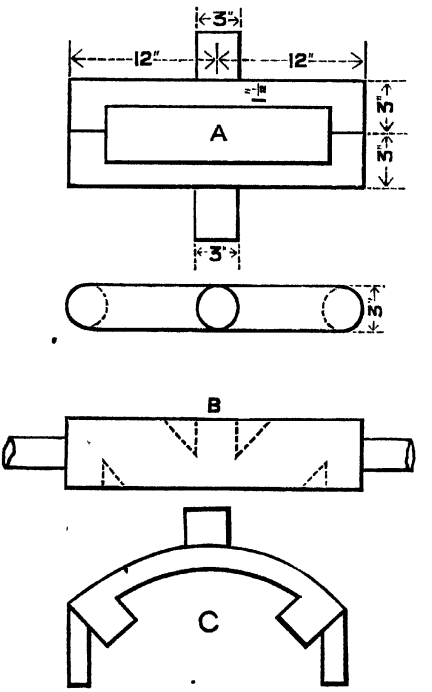


Finished forging of mild steel centre for governor gear.

the centre line, then mark off depth of hoop, 15 ins in this case. Set the compass from point C, this gives the curve of the plate before being bent round.

See pages 50 and 51.

The following sketches show a pair of links for engine work. Letter A shows finished forging; B shows where marked down ready for being drawn

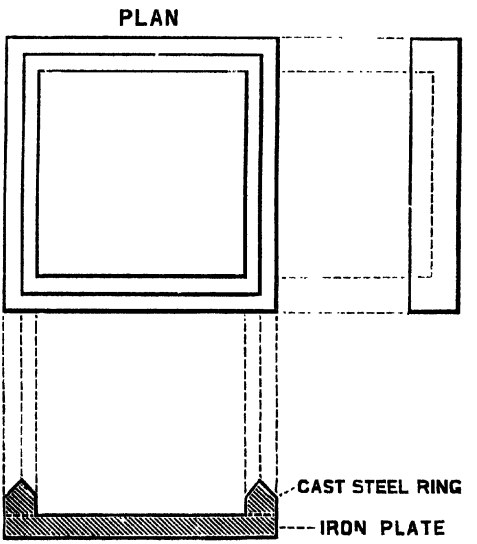


out; C shows link bent for rounding centre part in swages under hammer, afterwards straightened and end bosses finished on anvil or in standing dies.

CHAPTER VI.

Die Making.

Die making is simply welding cast steel to iron. For a die as shown above a cast steel square hoop



Section of die.

Welding cast steel to iron in making a die for press work.

is made first and welded on to an iron plate. The most important thing is not to overheat the cast

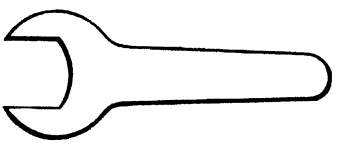
steel. Two fires are generally used, one for the ring and one for the plate. Have the plate at a good welding heat, and the cast steel hoop at a much less heat. When the plate is hot bring it out on the anvil and clean it with a wire brush. Next apply the following compound freely, take the plate under the hammer, add another handful of borax, and place the cast steel on top. A few blows with the hammer will then make a sound weld.

Welding Compound.

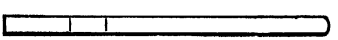
Crushed baked borax six parts; crushed raw borax ten parts; two handfuls of fine borings. To prepare this compound, crush the borax and put it in an iron pan on a slow fire; allow it to boil and cool down again, then crush as before and mix with the raw borax and borings.

CHAPTER VII.

Press Work.

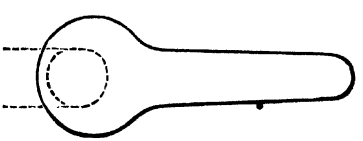


Spanner for press work.

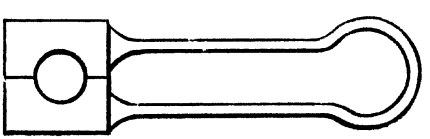


Finished Spanner.

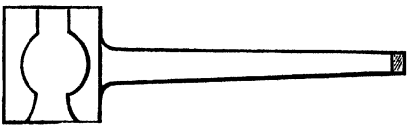
Bar roughed out.



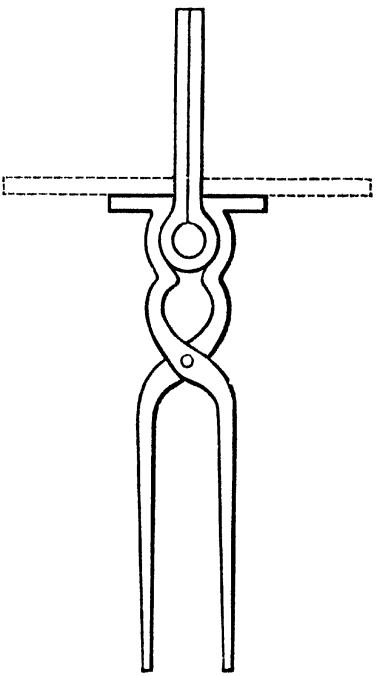
Hole punched and cut.



Swage.

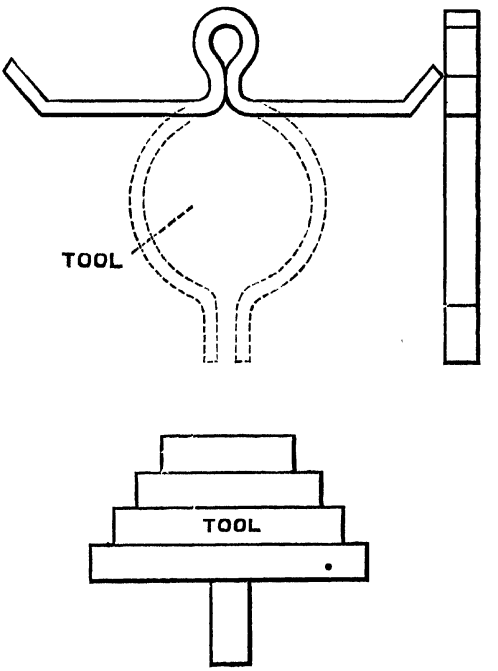


Plan of bottom part of swage.



Tongs for holding and opening out a brake strap before being bent round. The two grips are for different centres.

BRAKE STRAP.



Bending a brake strap. The tool shown is used for different sizes.

FORGING A ROUND KEY.

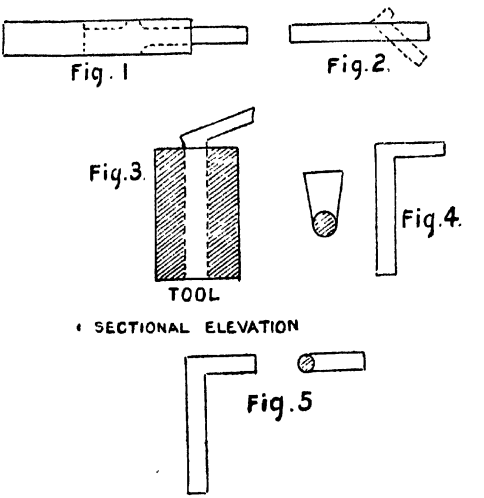


Fig. 1.—Bar roughed out.
Fig. 2. End slightly bent.
Fig. 3.—Piece in tool.
Fig. 4.—Finished roller key.
Fig. 5.—Finished knock off.

Roller key and knock off, both used together in press work.

The end is drawn out and then headed in bolsters, as shown in Fig. 1. A flat bar is used for spreading the piece to the desired length. It lengthens the

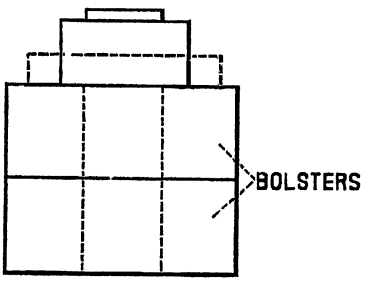


Fig. 1.

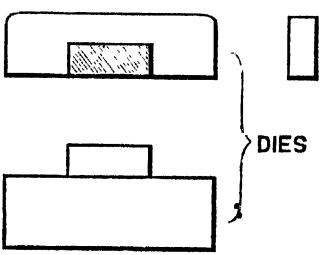
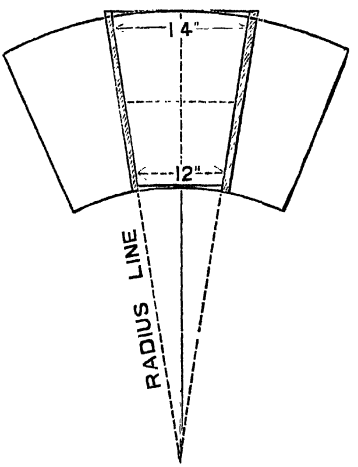


Fig. 2.

Making Eccentric Rod End.

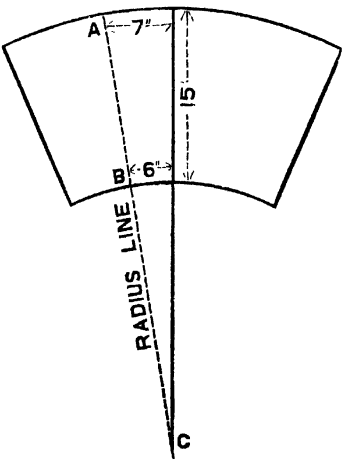
piece without widening it too much. The end may be stamped in top and bottom dies, as shown in Fig. 2, but the first method is the better for engine work.

The following sketch shows how to make bevel hoops in steel or sheet iron. First, mark out the hoop full size on a board, or if very large on the floor. Draw two parallel lines cutting the inner and



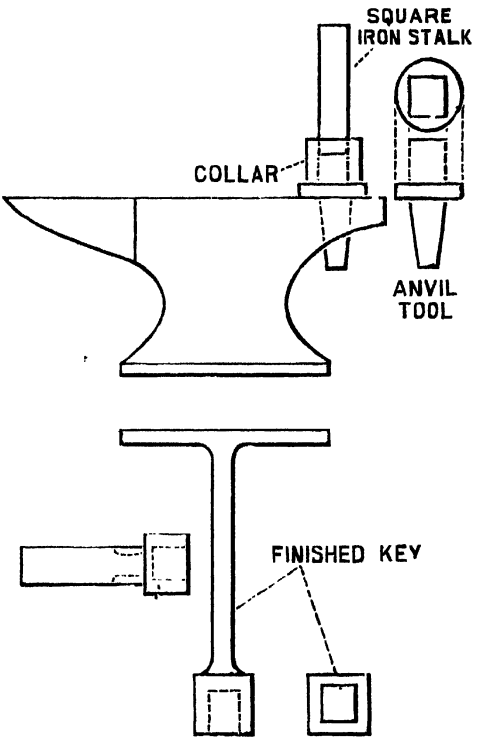
Sketch showing a bucket or bevel hoop. The dotted lines show where to scribe top and bottom of bevel before bending plate. For length of hoop, measure as an ordinary ring from centre of hoop.

outer circles, and join the points where these lines cut the circles by two lines meeting inside. The point where they meet is the centre for the compass or trammel which should then be set to the circles for scribing.

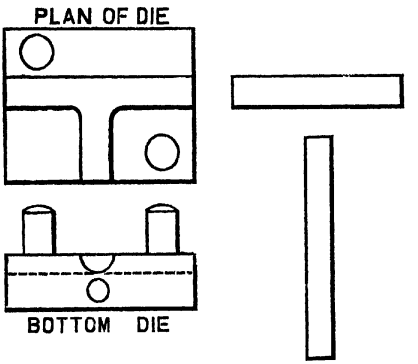


ANOTHER METHOD OF MAKING A SQUARE BOX KEY OR TAP KEY.

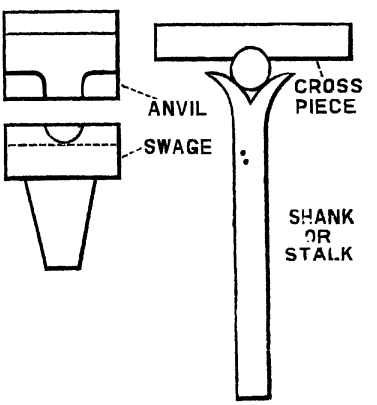
First make a collar round on the outside, and square on the inside. Next get a piece of square iron of the size of the inside of collar. Have a welding heat on both pieces, and place the collar on the square anvil tool, and the square iron inside the collar. A few blows on top of the square iron will make a good weld. Next have another welding heat and a mandrel for the inside, and square up to size. When the collar end is finished, have a pair of narrow swages for the neck, then draw the stem part out to correspond.


SQUARE
IRON STALK
COLLAR
ANVIL
TOOL
FINISHED KEY

MAKING A T-END FOR SQUARE BOX KEY.



When using dies no jumping is required. The two pieces are put straight in the die.



Where no dies are available, top and bottom swages for anvil are very useful, as shown. The cross piece is jumped in the middle, and the end of stalk is split. The parts are stuck together, again heated, and welded in the swages.

A Few "Don'ts" for Blacksmiths.

Don't work with a dirty fire. A clean fire makes a clean heat, especially when welding.

Don't use too big a piece of iron in the swages. When nearer the size it will be more easily turned, and perhaps save the swages.

Don't harass the hammer-boy when it's not his fault that things are not going well.

Don't work with hot tongs.

Don't leave the scrap to be trodden on.

Don't ponder over a waster. Start afresh at once, or your waster will waste more time.

Don't use your hand hammer for a punch—it's dangerous.

Don't alter other men's tongs without permission.

Don't say "that's near enough" when a job is done. Say "that's all right".

Don't mistake your mate for a steam-hammer.

Don't work iron or steel when cold.

Don't use tongs under the hammer without coupling on.

Don't force the callipers when trying them on; it won't make the iron any smaller.

A Few "Don'ts" to the Toolsmith.

Don't forget to air the water in the trough the first thing in the morning.

Don't put the blast on full when putting tool-steel in the fire; let it heat very gently for a start.

Don't keep the steel in the fire when hot, as it is likely to burn even when the blast is off.

Don't forge cast-steel after it drops to a dull red heat, as it spoils the steel, and is likely to make it crack when hardened.

Don't forget to brand all tools with the initials of the maker of the steel, so that you can tell it and know how to treat it next time.

Don't try to cut cast-steel when cold.

Don't worry; heat slowly; work briskly.

Things Not to Forget.

Don't forget to air swages and tool in cold weather before using them under the hammer.

Don't forget to turn the iron towards your mate when swaging under the hammer; it will keep the loose swage on.

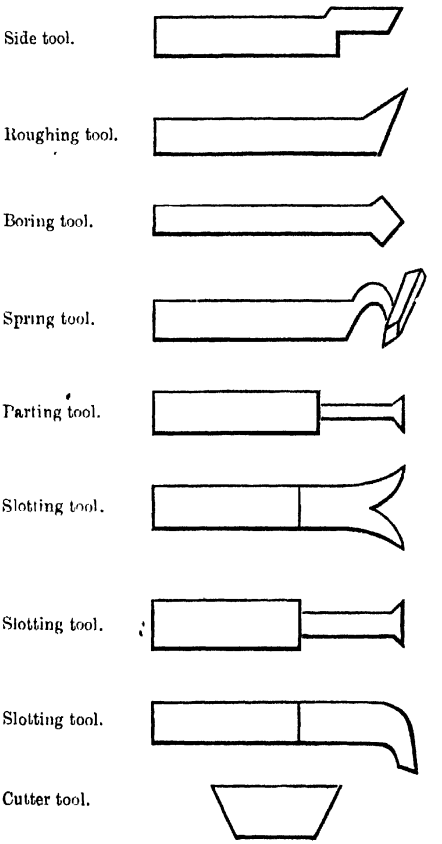
Don't forget that a long scarf is best for welding steel; it is not so liable to slip back.

Don't forget to form the job in your mind before you form it on the anvil.

Introduction of the Apprentice to the Tool Fire.

We will now introduce our apprentice to the tool fire, and begin by showing sketches of tools used by some of the various machine men. It is very important that the toolsmith should know the names

Various Machine Tools.



and uses of the tools he has to deal with, which is the cutting edge, where to allow for clearance, etc. Most of the following tools are made of high-speed steel.

NAMES OF SOME CHISELS.

Flat.
Cross-cut.
Diamond-point.
Gouge.
Cow-mouth.

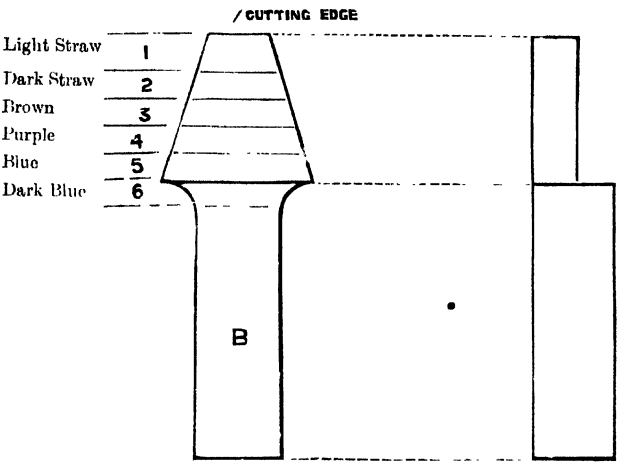
The toolsmith has to deal mainly with two kinds of steel, ordinary cast steel and high-speed steel, and with three degrees of hardening. We will first take high-speed steel, which is not very difficult to harden. This steel, and indeed all tool steel, must be heated very slowly in a clean red fire, and must not be allowed to remain in the fire after it is hot, even if the blast is off. When steel is heated too quickly the outside of the steel gets hot before the inside, and if worked in this state the steel will crack on the surface and so be spoiled and useless when hardened. High-speed steel should be kept from water, and should not be put on the damp floor when hot. It should not be worked below a dull red heat. Great care should be taken that it is not overheated, and it should be hardened in a cold blast.

The ordinary cast steel requires every attention and care if satisfactory results are to be obtained. We will first take a chisel, which, after being drawn down, must be, what is termed, tempered or hardened. To make a chisel that will stand a test is a very important part of the toolsmith's duty. In tempering,

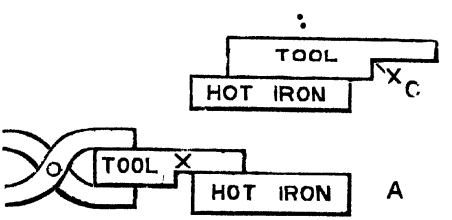
place the chisel in the fire without the blast on and heat the end for about 1 in. long with a gradual heat, that is, don't let the heat stop at one particular spot, but have a dull red heat about 1 in. up, and then taper to a black heat. This prevents the chisel from breaking at the part where it has been dipped. Dip the chisel once slowly and horizontally in the water, then rub the point with a piece of stone and watch the colour until it becomes a light straw at about $\frac{1}{4}$ in. from the point. Now dip it in the water very quickly and out again, rub with the stone, and allow the colour to run, this time to a light blue, and finally dip off.

The following sketches show how a finishing tool is hardened, and also a scale of the various colours as they appear when the steel is placed on the hot iron. After the tool has been heated to a bright red dip it straight away in the water. When thoroughly cold, rub the part to be hardened with a piece of emery cloth to give it a polished surface again. The part just cooled off will be extremely hard, and show a white colour. It now requires, what is generally termed, "letting down," that is, bringing from extreme hardness to the proper temper, so that it will not break by being too hard or the corners rub off by being too soft. Place a piece of iron at about red heat on the anvil, and lay the tool on it, as shown in Fig. C. Don't have the iron too hot, but have another piece ready in the fire for use when the first piece gets too cold. It is better to use two or three pieces than to have one piece too hot, as it allows the temper to run more evenly and gently. When the light straw colour reaches the shoulder X draw, the

tool back as shown in Fig. A. The colour will then very quickly run to the end of the tool, which must be quenched off immediately. The tool is now ready for use.



Scale of colours in hardening.



Hardening process of a turner's finishing tool.

NAMES OF SOME HIGH-SPEED TOOL STEELS.

Glen Rapid.
Bowler.
Edgar Allen.
Novo.
Triple High Speed.
Mushet.
Ultra Capital.
Super Rapid.
Self-hardening.
Triple Mushet.
New Capital.

CASE HARDENING.

Our next kind of hardening will be case hardening, which, as the name indicates, is hardening steel or iron on the case or outside to a certain depth. Opinions differ as to how far case hardening penetrates below the surface, but it may be assumed to be not more than $\frac{1}{8}$ in. in depth. It is generally applied to articles that are likely to wear on the surface by friction. Most parts of engine work, especially pins, etc., are so treated. It can be used for cast steel and mild steel, and also for iron, with a proportionate amount of success. For mild steel the article should be dipped when a little hotter than for cast steel. In case hardening we follow the same rules as in other hardening. If the article to be hardened has a polished surface it should not be so overheated as to scale it, as it will afterwards show little black specks, and will be very difficult to polish to the same degree again. First, get the article to be hardened to a dullish red heat

and apply powdered potash to the surface. The best way is to use a piece of hoop iron to put the potash on and heat it. When the potash begins to melt rub it over the surface by the aid of the hoop iron. This prevents a scale from forming on the steel, and allows the potash to penetrate. After it has become absorbed put the article back on the fire for a few minutes, take it out again and rub it over with the iron. Finally, dip it off in the water, moving it about in a horizontal position if it is anything that is likely to bend, as this keeps the steam from coming in contact with the hot steel and prevents it from bending.

All steel to be hardened in this way should be heated in a stove, which heats more evenly and slowly. If there is no stove kept in the smithy, a very good plan is to build a temporary one of loose fire-bricks round the ordinary fire, using an iron plate for the top. This keeps all draught from the steel while heating, or the article may be covered with a plate. The same conditions should be maintained when letting down hardened steel, that is to say, all draughts should be avoided, as they prevent the temper from rising.

The Hardening of Twist Drills and Screwing Taps.

In the hardening of twist drills and screwing taps in an ordinary fire without a stove and proper appliances, great care must be taken in order to obtain fairly good results. As before mentioned, stoves are best for hardening purposes to secure an even and slow heat, it being most essential that the heat should be the same all over before anything is dipped

for hardening. In hardening a screwing tap or twist drill take a piece of iron piping and put the drill or tap inside it, cover up the end so that the pipe will act as a stove, then cover up in the fire and heat very slowly. When at a dull red, take it in a pair of tongs and dip it horizontally in the water, moving it gently up and down so as to keep the steam from coming in contact with the steel, thereby preventing the article from bending. When perfectly cold polish up again, hold it over the fire, but not on the fire, and keep pouring oil from the oil-can on the tap. The best plan is to have something to rest the tongs upon 4 or 5 ins. higher than the top of the fire, so that you can keep turning the article round at a distance from the fire. Don't let the article get dry, but keep lifting it off and pouring on the oil. Now take particular notice when the oil begins to smoke. Before it gets to a dark smoke, or better still, as soon as the oil blazes all over the tap, it is ready for dipping.

In the hardening of light springs an open fire will do, the piping therefore not being required. The same treatment with the oil, however, is necessary.

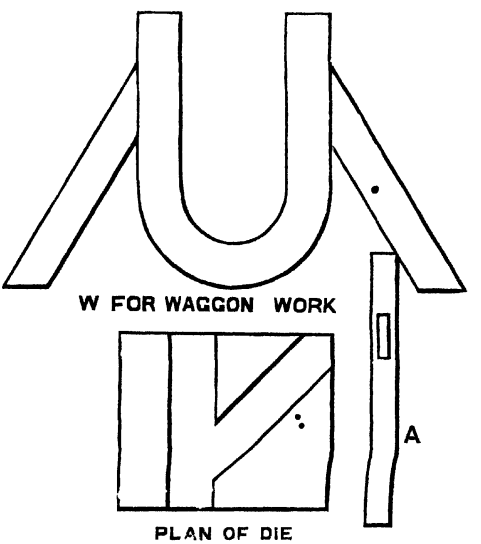
Annealing.

In most large works a stove is provided for this purpose, but in smaller shops a pit may be made in the floor, either bricked round or not. The steel forging is heated and placed in fine ashes in the pit, a few handfuls of sawdust being placed over it. A cover plate is put on and the forging will then keep hot for days. Small articles should be heated and buried in lime.

CHAPTER VIII.

Waggon Work.

W for waggon work made in a die. No scarfing or jumping is required, the parts being simply dubbed



together in the die. For repairs where no die is at hand, split the edges, as shown in figure A, of the **U** piece, and weld the wing in on the anvil.

Fig. 1 shows spring hoop for waggon work, and the place to weld the strip in mandrel. Fig. 2 shows a buffer hoop in position on the anvil when welding.

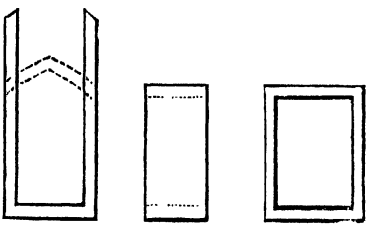


Fig. 1—Spring hoop.

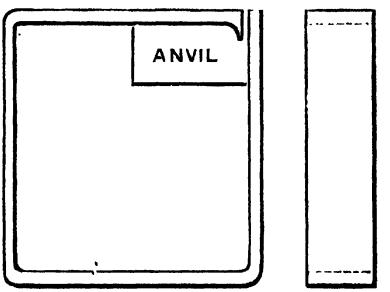
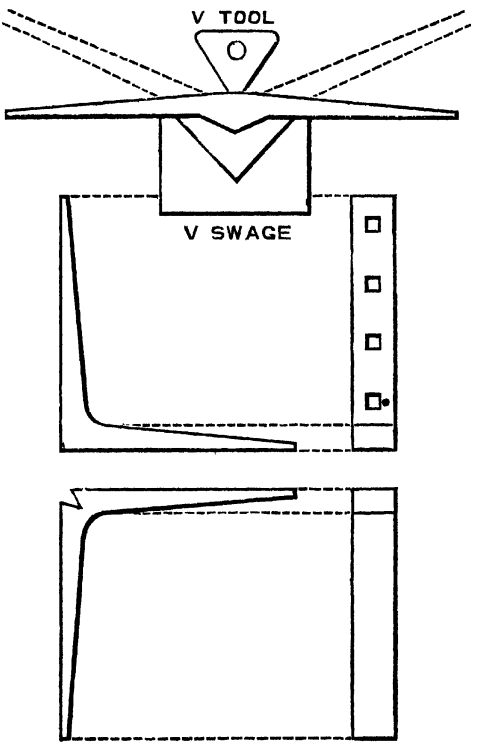
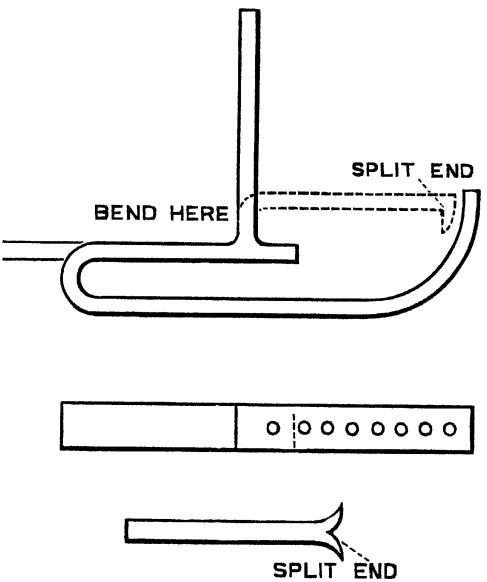


Fig. 2—Buffer hoop.

The front is struck with the backing hammer, and the hand hammer is used on the top at the same time.



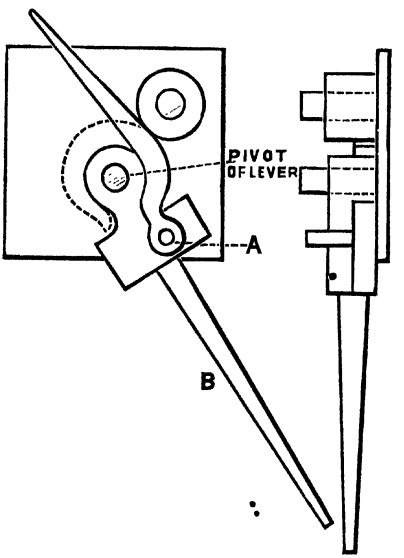
Two ways of making a knee for waggon work. The first is forged solid and the second is glut welded.



Back for waggon brake lever.

The end of the upstanding part is split to save jumping before it is bent down and welded to the curved part.

Many hooks are now stamped, but for strength and durability hand-made ones are best. The eye end A should be bent slightly and then cooled out before putting it in the tool. It should be brought to a proper heat, fitted in the tool, and pulled round to shape. Hooks should always be made of best iron.

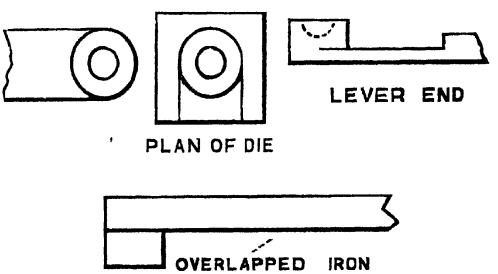


Tool for bending hooks.

Stamping.

Dies for stamping by the steam hammer, a process similar to drop stamping, are all made in a similar way. In some forgings an article can be stamped by the use of a single die, while in others a top and

bottom die must be used. The impression of the forging to be made is sunk in the die. It should in all cases have a little taper, so that the forging will come out more easily, and should be machined out in the machine shop from the solid block, and then hardened on the face with potash. Studs should be screwed in the bottom die at the corners, and holes made in the top die for a guide. Small $\frac{5}{8}$-in. holes should be made in the sides for lifting the dies on and off the hammer. Forgings can either be made



from the solid, that is, roughed out from the bar, or from ordinary round iron overlapped, as the above figures show.

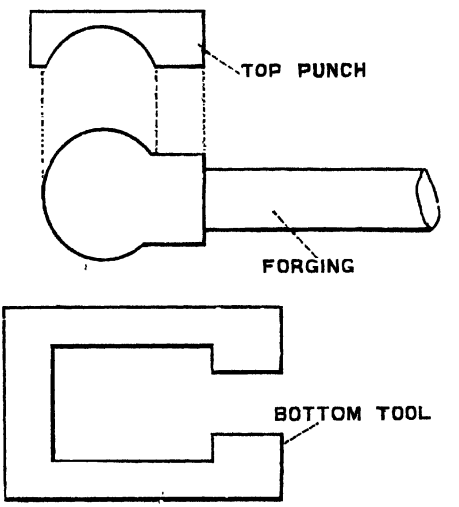
All that is required in making a lever end of this description is a single die and a piece of round iron turned over at the end as shown. With a good welding heat the lever end is readily formed.

It is unnecessary to show the various stamps or dies that can be used under a steam hammer, since practically everything that can be made with a drop stamp can be made by a die stamp, provided the

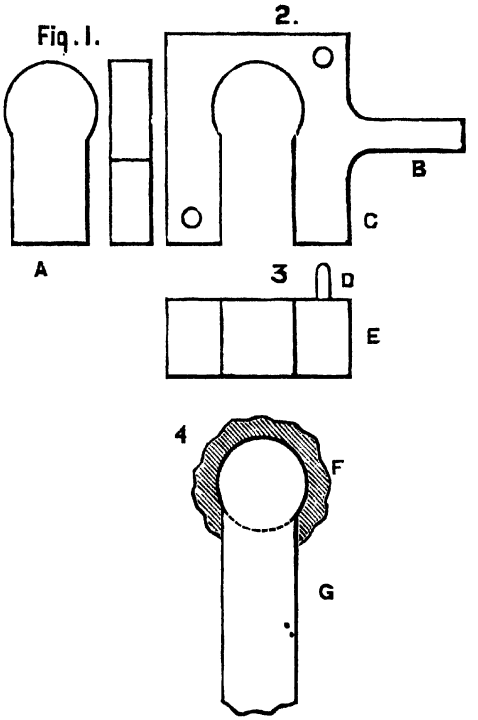
hammer is heavy enough. The metal used for forging in dies depends upon the nature of the particular article to be made. Levers and rods for engine work should be made of mild steel, and should be roughed out before being finished in the dies. Joints can be made from the solid or by welding the joint end on to the rod, according to the use to which the article is to be put. Where possible, round iron is best for stamping. Hooks for sling chains should be made of best iron, and can be produced very easily and cheaply by stamping, since, in most cases, all that is required is a piece of iron bent to the shape of a crook and placed in the die. Dies should be kept cool during the intervals of use by pouring on water on them after use. They should be wiped off before being used again. When a number of forgings of one kind are to be stamped, it is worth while having what is called a "trimming die," that is, a die for cutting off the flash that remains after the article has been stamped. This die need not be made of solid steel; it will do just as well made from iron with a piece of thin cast steel riveted on the face. It must be made to the outside shape and size of the article, with the top piece similarly shaped. In some cases the flash can be cut off when the forging is cold, while in others it must be warm. This depends upon the thickness of the flash and the size of the forging.

The following figures show a trimming die for cutting off the fray or flash from a lever end after it has been stamped. Fig. 1 shows the punch; Fig. 2 the plate or guide for the punch, which fits on top of the tool. The tool is the same shape in plan as the

plate, except for the handle. There should be two pegs in the tool and two holes in the plate as shown, the length of the pegs being according to the thickness of the flash, so that they will not be above the level of the plate. Fig. 4 shows the lever after



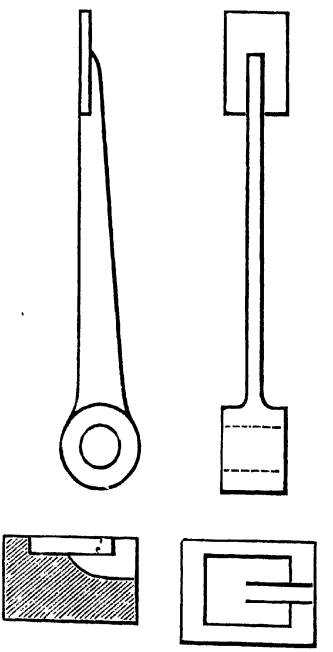
stamping and ready for trimming up in the tool. Forgings, for instance spanners, that are stamped by top and bottom dies do not require a guide plate for the trimming tool, as the flash is central. Tools of the shape described are very useful for stamping washers, etc.



Trimming levers. Stamped in single die.

Sketch of trimming tool suitable for joints made from the solid with the flash central.

FOOT LEVER FOR BRAKE GEAR SHOWING DIE FOR STAMPING FOOT END.



Section of die. Plan of die.

DETAILS OF LARGE AND SMALL DIES.

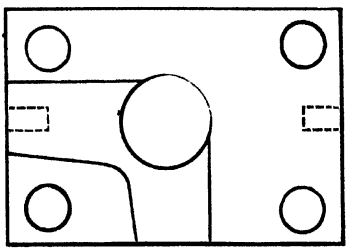


FIG. 1

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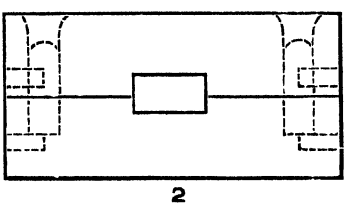

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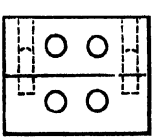

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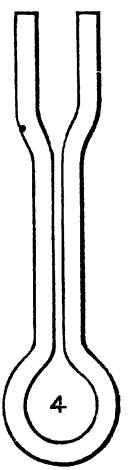

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Figs. 1 and 2 show a die for a central boss angle lever.

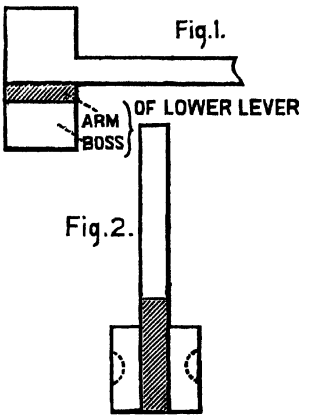
Fig. 3 shows where holes are placed in a small die for lifting it on and off the hammer. Two pegs are sufficient for guides on small dies. Sufficient space should be left between pegs and forging to allow for flash.

Fig. 4 shows a handle for lifting small dies.

Fig. 5 shows a nipple for fixing in bottom of die.

A mild steel angle lever may be made in the following manner: Rough out two pieces each like an ordinary straight lever and place them back to

STAMPING AN ANGLE LEVER.



back in the die as shown in Fig. 1. Two fires are generally used for heating, one for each piece, and two mates are employed, standing at the two sides.

Fig. 2 shows the two levers stamped into one.

WAYS OF STAMPING A LEVER.

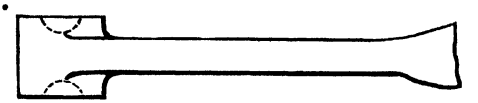


Fig. 1.

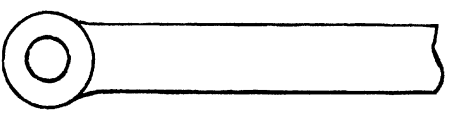


Fig. 2.

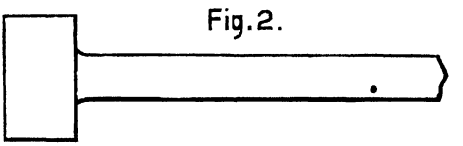


Fig. 3.

Fig. 1 shows finished lever stamped.

Fig. 2 shows lever drawn from the solid ready for stamping. It should be smaller in diameter to go in the die easily, and thicker to fill up the die when finished.

Fig. 3 shows a lever made from round bar which should be large enough to form the shank. One piece is cut partly through and turned over, and the other piece is welded on.

OLD AND NEW WAYS OF MAKING A LEVER.

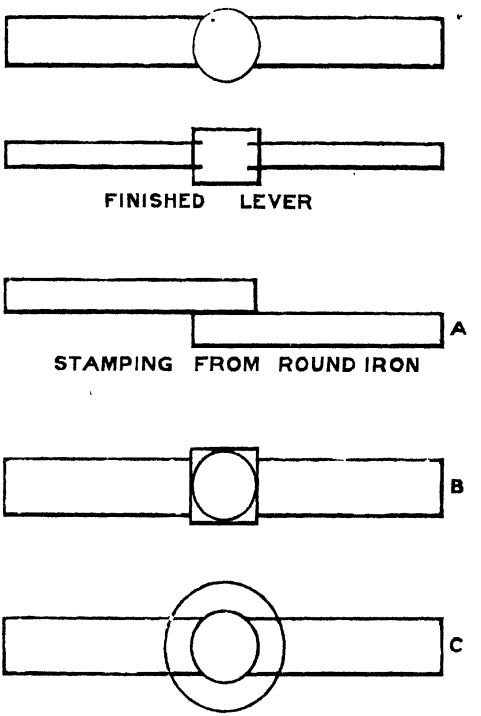
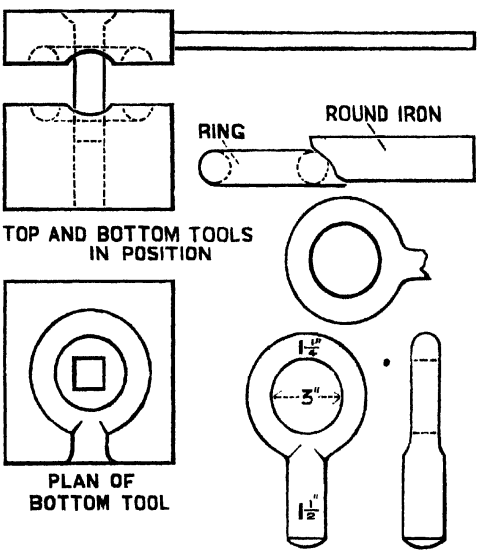


Fig. A shows how it would be stamped in dies under the hammer from two pieces of round iron.

Fig. B shows corners cut off and rounded up with swage.

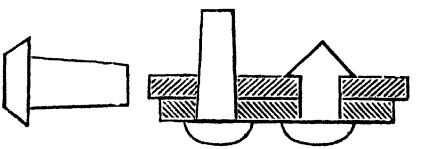
Fig. C shows boss made from two washers.

MAKING EYE BOLTS.



To make eye bolts in this tool first bend the iron ring and make a scarf in the ordinary way, then lay it in the tool. Lay on a piece of round iron, as shown, to form a scarf, heat both pieces and dab together on the anvil, then take another welding heat and place it in the tool.

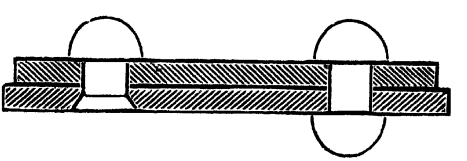
RIVETS.



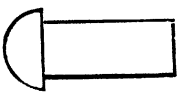
Pan-headed rivet. Rivet in position for head to be formed. Conical head finished with hand hammer.

ROLLED SECTION OF IRON AND STEEL RIVETS.

Half round. Flat. Square. Round.

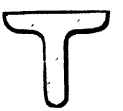


Rivet with counter sunk head. Snap-head rivet finished.

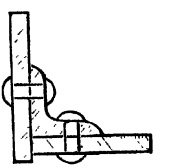


Snap or cup head rivet.

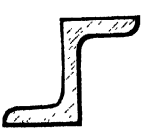
Angle iron.



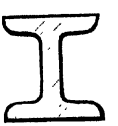
T iron.



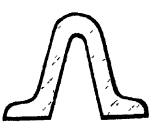
Plates at right angle with angle iron bars.



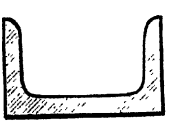
Double T-iron.



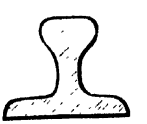
Rolled joist.



Bridge rail.



Channel iron.



Standard rails.

To find the size of square bolt head or nut required for a given size of bolt, take $1\frac{1}{2}$ times the diameter of the bolt and add $\frac{1}{8}$ in. For example, for a 1 in. bolt the head is $1\frac{5}{8}$ in. square; for a $1\frac{1}{4}$ in. bolt the head is 2 ins. square. The sizes for various bolts are given in the following table: –

TABLE OF IRON USED FOR MAKING SQUARE BOLT HEADS AND SIZES OF SQUARE BOLT HEADS.

Diameter of Bolt.	Size of Iron.	Size of Bolt Head.
$\frac{5}{16}$ in.	$\frac{1}{2}$ in. × $\frac{1}{4}$ in.	$\frac{7}{8}$ in. sq.
$\frac{3}{8}$,,	$\frac{1}{2}$,, × $\frac{1}{2}$,,	$1\frac{1}{16}$,, ,,
$\frac{7}{16}$,,	$\frac{3}{4}$,, × $\frac{1}{2}$,,	$1\frac{1}{4}$,, ,,
$\frac{1}{2}$,,	$\frac{1}{4}$,, × $\frac{5}{8}$,,	$1\frac{7}{16}$,, ,,
1 ,,	1 ,, × $\frac{1}{2}$,,	$1\frac{5}{8}$,, ,,
$1\frac{1}{4}$,,	1 ,, × $\frac{5}{8}$,,	$1\frac{13}{16}$,, ,,
$1\frac{1}{4}$,,	1 ,, × $\frac{7}{8}$,,	2 ins. ,,
$1\frac{3}{8}$,,	$1\frac{1}{4}$,, × $\frac{7}{8}$,,	$2\frac{3}{16}$,, ,,
$1\frac{1}{2}$,,	$1\frac{1}{4}$,, × 1 ,,	$2\frac{3}{8}$,, ,,
$1\frac{5}{8}$,,	$1\frac{1}{4}$,, × $1\frac{1}{4}$,,	$2\frac{1}{2}$,, ,,
$1\frac{3}{4}$,,	$1\frac{1}{4}$,, × $1\frac{1}{4}$,,	$2\frac{5}{16}$,, ,,
2 ins.	$1\frac{1}{4}$,, $1\frac{1}{4}$,,	$3\frac{1}{16}$,, ,,
$2\frac{1}{4}$,,	2 ins. × $1\frac{1}{4}$,,	$3\frac{1}{2}$,, ,,
$2\frac{1}{2}$,,	2 ,, × $1\frac{1}{2}$,,	$3\frac{5}{8}$,, ,,

To find what size of square can be made from a given size of round iron, a rough method is to multiply the diameter of the round bar by 7, and take the nearest whole number of the result as the side of the square. For example, for a 3-in. round bar, $7 \times 3 = 21$; a 2-in. square can be made. For a 4-in. round bar, $7 \times 4 = 28$; a 3-in. square can be made. This approximate method is useful in roughing down work.

In calculating the length of iron for a hoop,

multiply the inside diameter of the hoop by 3, add three times the thickness of the iron used, and ⅛ in. for every 21 of the result. Allow for welding and jumping. For angle iron hoops the diameter is measured from outside to outside of the root or corner.

Piece-Work.

Piece-work, or payment by results, is a system that is likely to be adopted sooner or later in all engineering works throughout the country. Therefore the sooner we study the subject the better it will be for ourselves, the employer, and the trade generally. Under fair conditions and prices, it is more interesting and profitable to the workman than day work. The three most essential things for a satisfactory piece-work system are, good tools, an orderly method, and a good mate. The first thing to be seen to before starting is the suitability of the tools for the particular job you are about to do. If it is hammer work you should see that you have proper tongs, swages, cleavers, etc. If a large number of one particular article is required it often pays to make special tools for the job at the beginning. If you are working under the hammer, set your mind on doing a certain quantity of work in one heat, to avoid having to go over the same part twice. Don't work after the iron is cold, but leave off, and do the same quantity of work every time. Roughing out should be done as neatly and quickly as possible, leaving the greater part of the time for finishing off the work, if this has to be done on the anvil. Always work on a system adapted to the

job you are engaged on. For example, if you can arrange to have one piece heating in the fire while you are drawing out under the hammer you can sometimes keep up a continuous process and save a great amount of time, as most of the time must be saved in roughing out. If you are making joints or levers do all the roughing out first and finishing afterwards in different stages. If you are on light work, such as bolts, cut off all the iron for the day, bend all the collars, and then weld all the heads on together, taking the pieces in pairs so that you always have one piece in the fire while you are working the other one. The same applies to collars. Cut off the pieces to the desired length, bend round, and do all the welding at the finish. In fact, in piece-work it is not always a matter of speed or hard work, but of the particular system or method of working you adopt.

The Duties of a Foreman Smith.

Before explaining the duties of a foreman, I should like to say a few words to the would-be foreman. First of all, I would recommend him not to stop too long at one shop, unless it is that of a very large firm, and there is a chance of obtaining an under-foreman's job. As most applicants for a foreman's job know, getting the first situation is the most difficult, because very often an employer prefers a stranger, even when a casual vacancy occurs. An old hand may be as competent, ambitious, and energetic as a stranger, but the employer looks for experience, and judges it by the number of places you have worked at. Perhaps this is a right view

to take, because a man would have more control over a strange shop than over his old shop mates. Again, it does not always follow that the best workman makes the best foreman. This is a well-established fact. But the foreman must have qualifications which the best workmen have not always got. He should, first of all, thoroughly understand his trade, be a deep thinker, and understand the outlook and temperaments of the various classes of men he has under him. He must be sociable, and yet firm, and a man of ideas. It is his duty to see that the work is turned out in good condition, and as quickly as modern methods will allow. He should see that the apprentice is properly looked after, and be as sociable with him as his position will allow, encouraging him to come to him for counsel and advice on all matters connected with his work. He should see that the work is properly dealt out, giving the light work to the man most suited for it, and the same with the heavy work, as some men are good on light work, and others on heavy. He should see that the shop is kept clean and tidy, that all tools and dies are kept in good order and repair, and that another job is always ready for a man when he has finished the one he is on, so that there is no waste of time. If a man is not used to drawings, he should give him a full explanation of what is required. This is especially necessary for an apprentice. He should be able to give a quick decision of the time and price of any work that comes under his control. He should thoroughly understand drawings, and be able to make a good freehand sketch. He should be good at figures and arithmetic. He should see that

no work is done in the smith's shop that could be done cheaper in the machine shop, and that no work is done in the machine shop that could be done cheaper in the smith's shop, since, by agreement between the foremen of these two departments, much time and expense can be saved to the employer. He should also be a good timekeeper, sober, steady, and industrious in all things, with a desire independent of the financial point of view to attain his highest ambition,—progress and promotion.

THE END.

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